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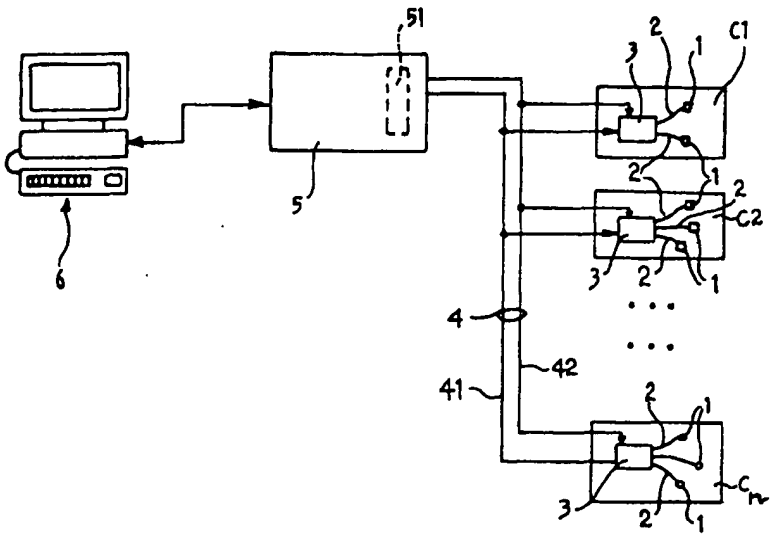

(57) Abstract

A method for actuating faults on a plurality of modules (C1, C2...C_i...C_n) of electronic equipment entails equipping said modules (C_i) with respective fault actuating means (1), and associating said modules (C_i) with control units (3) of said respective fault actuating means (1). These control units (3) can control the selective actuation of faults by the fault actuating means (1) depending on respective fault actuation control signals. The various control units (3) are connected by means of a bus structure (4), preferably of the balanced serial type. Means (5, 6) are provided for generating the fault actuation control signals and sending them towards the control units (3) through the bus structure (4).

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METHOD OF AND SYSTEM FOR ACTUATING FAULTS

The present invention relates in general to fault actuation or insertion techniques used to test the operation of electronic equipment.

In electronic equipment (especially if very complex systems are involved: by way of non limiting example, reference can be made to switching exchanges for telecommunication networks), the need often arises, also during the development and engineering phases, to check and test the behaviour of the equipment in the presence of particular fault conditions. This especially regards the testing phase of the equipment and its parts, the diagnosing and/or fault identification functions and the automatic reconfiguration functions with which such equipment is often provided in order to assure (at least partially) continuity of operation even in the presence of faults.

This need is met by means of devices that allow fault actuation or insertion (hereinafter the two terms shall be used indifferently) in pre-set points of the equipment to be tested. Generally speaking, this usually takes place by forcing certain points of the equipment under test to a fixed signal level, corresponding, for instance, to a logic "0" or to a logic "1".

The prior art document WO-A-97/33180 provides, in addition to an illustration

of the state of the art, the description of a probe for fault actuation devices which among other advantages:

- renders wholly flexible the reproduction of the fault conditions,
- does not disrupt the operation of the equipment or system undergoing the test,
- is intrinsically not cumbersome,
- is suitable for automating the testing operations, and
- has very low costs.

Document WO-A-97/37234 describes a constructive module of an electronic telecommunications equipment associated with means interfacing it with a test and diagnosing system, which means can be mounted at least temporarily and in a non invasive manner on the module itself. That module comprises actuation probes of the kind described in WO-A-97/33180, monitoring probes, shielded micro-coaxial wires connected on one end to said probes and on the other end to connectors provided on the module, as well as conditioning devices, associated to the connectors to provide control signals to the actuation probes, to allow the insertion of signals on modules based on different technologies by using the same type of command signal provided by the test and diagnosing system, and obtaining a galvanic isolation between the test and diagnosing system and the modules under test.

The solutions described above are included in the testing system known under the registered trademark THRIS™.

The present invention is intended to take into account the fact that in complex electronic equipment (such as switching exchanges of telecommunication networks, to refer to the example made above) it is often necessary to perform simultaneously or nearly simultaneously the insertion of faults even in points which are quite distant from one another. Hence there is a need to provide means to perform a centralised fault actuation function, by reaching boards or modules that are placed even at considerable distance from one another.

Theoretically, one could conceive of centralising the fault actuation action simply by providing the probes located in the various points involved with sufficiently long connecting cables, leading to a central fault actuation module. However, this solution is not practicable because of both the intrinsic complexity of the system,

linked with the number of cables that would become necessary, and because it would in fact be unusable, especially in consideration of the frequency range of the signals concerned.

According to the present invention, the need expressed above is met thanks to the method having the characteristics defined in claims 1 to 5 that follow. The invention further relates to a system for carrying out such method, as defined in claims 6 to 12.

The invention shall now be described, purely by way of non limiting example, with reference to the accompanying drawings, wherein:

- Figure 1 shows, in the form of a block diagram, a typical configuration of a system according to the invention, and
- Figure 2 shows in greater detail the connections among some of the parts of the system shown in Figure 1.

In essential terms, the system shown in Figure 1 is intended to allow the selective actuation (or insertion) of faults into a plurality of modules (for example respective boards) C1, C2 ... C_n of an electronic apparatus or system such as, for instance, a switching exchange for telecommunication networks. Hereinafter, also with reference to Figure 2, the generic module shall be indicated as C_i

The structure and characteristics of such modules have no relevance for the invention. However, they must comprise one or more points wherein a fault actuation is to be performed. To this end respective probes 1 are applied in a known manner in these points: for instance and advantageously, the probes 1 can be as described in the document WO-A-97/33180 mentioned above. Through respective connecting conductors 2, usually comprising shielded micro-coaxial cables, the probes 1 are connected to respective fault actuation modules 3 having the structure that shall be better described hereafter.

An important feature of the invention is that the modules 3 can be in the form of printed circuit boards which can be associated (for instance by direct mounting, particularly by gluing) to the respective module C_i.

The reference numeral 4 indicates a balanced serial bus structure, made for instance according to the standard known as CAN-Bus, where the acronym CAN stands for Controller Area Network. Such bus is a serial bus able to reach distances in the order of 500 metres and is particularly suitable, thanks to its balanced

structure, to withstand disturbances and interference. Although the Figures show only two wires, the bus 4 actually comprises four wires, two of which (indicated in the whole by reference numeral 41 in the drawing) are intended to perform the actual bus function (i. e. signal transmission function) and two (reference 42 in the drawing) are intended to supply power in a distributed manner to the bus interface devices, as will become more readily apparent below.

In the diagram in Figure 1, the reference numeral 5 indicates a unit (rack) known as VXI. In practice this is a unit that, starting from the control signals provided by the operator in a work station 6, usually a personal computer, processes the logic signals which, transferred towards the modules 3, determine the fault actuation by the probes 1. The operation of unit 5 takes place according to criteria known in themselves, particularly in regard to their application in the aforementioned THRIS™ system. These criteria therefore do not require to be illustrated in detail herein, also because in themselves they are not relevant for purposes of embodying and understanding the invention.

This also applies to accessory functions (not shown herein) which normally are provided in a fault actuation system, i.e. the detection and analysis (for instance by means of amperometric probes) of electrical events, such as current absorption, which may arise at the fault points, and/or the presence, within the tested equipment or system, of means for diagnosing and/or identifying the fault, reconfiguring the equipment etc. All such functions possibly are able to co-operate with the fault actuation system.

Of course the unit 5 is provided with a board 51 - known in the art - allowing it to be interfaced with the bus 4.

In Figure 2, reference numeral 7 identifies in general the circuits (shown herein in a deliberately schematic form, also considering that the specific embodiments can widely differ) intended to drive the probes 1 through the wires 2. Any number of driving circuits 7 can be provided depending on the application requirements and on the intrinsic conditions linked to the nature and structure of the modules C_i. For instance, in an embodiment successfully used by the Applicant, up to fifteen outputs towards respective fault actuation probes 1 can be driven within each module 3. The various driving circuits 7 are controlled by a logic unit 8, typically a microprocessor.

The diagram of Figure 2 intends to highlight the fact that the part of each

module 3 comprising the driving circuits 7, as well as the microprocessor 8, is powered by means of the power supply voltage V_{cc} present on the respective module C_i. This part of each module 3 can thus be galvanically decoupled from the remaining part of the test system.

In the embodiment shown, the transfer of the signals from the bus 4 towards each unit 8 takes place through an optical coupler 9 whose receiving part 91 (typically a phototransistor) is associated to the microprocessor 8 and shares the power supply V_{cc} thereof starting from the board C_i.

The transmitting part 92 of the optical coupler (typically a light emitting diode) is instead powered, as is the respective interface device 10 towards the bus 4, by the power supplied by the bus itself (two-wire line 42).

In operation, the user identifies on the work station 6 (equipped with a specific software, such as the VEE software provided for the THRIS™ system) the module or the modules C_i to be tested and the faults to be actuated. The related commands are sent to the unit 5 and the actuation signals generated by that unit are transferred, through the bus 4, towards the board(s) concerned, which can be positioned even at a great distance within the measuring environment. As said, the boards are equipped with the respective module 3, that is able to interpret the signals coming from the bus 4 and to provide the driving circuits 7 with the signals for controlling the fault actuation probes 1.

The fault actuation and insertion action is thus remote controlled. There is no longer any need to move any element of the test system to the vicinity of the boards C_i to be tested. On the contrary, once the boards are set up for the testing campaign, it is possible to control any fault insertion from the work station 6.

The bus 4, which travels through the equipment, is optically decoupled from the actuation parts of the modules 3. Any high energy transients, caused by external noises, are thus unable to damage the equipment in the unit 5, or the boards under test; nor are they able to alter the results of the test.

The CAN-bus structure makes the bus 4 intrinsically robust and resistant against disturbances and interference coming from the external environment.

Of course, while the principle of the invention remains valid, the construction details and the embodiments can be widely varied with respect to the description and illustration provided herein, without thereby departing from the scope of the

present invention as defined in the claims that follow.

Claims

1. Method of fault actuation on a plurality of modules (C1, C2 ... C_i ... C_n) of electronic equipment, characterised in that it comprises the following operations:
   - providing said modules (C_i) with respective fault actuation means (1),
   - associating said modules (C_i) with respective control units (3) for controlling said respective fault actuating means (1); said control units (3) being arranged to control the selective fault actuation by said fault actuating means (1) according to respective fault actuation control signals,
   - connecting said control units (3) through a bus structure (4), and
   - sending (5, 6) said fault actuation control signals towards said control units (3) through said bus structure (4).

2. Method as claimed in claim 1, characterised in that it comprises the operation of adopting, for said bus structure (4), a balanced serial structure.

3. Method as claimed in claim 1 or 2, characterised in that it comprises the operation of powering at least a part (10) of said control units (3) through said bus structure (42).

4. Method as claimed in claim 3, characterised in that it comprises the following operations:
   - making said control units (3) with a first part (7, 8) for driving said fault actuating means (1) and a second part (10) for interfacing said bus structure (4),
   - powering said first part (7, 8) and said fault actuating means (1) through a power supply source (V_{cc}) for the respective module (C_i), and
   - powering said second part (10) through said bus structure (4).

5. Method as claimed in any of the previous claims, characterised in that it comprises the operation of mounting said respective fault actuating means (1) and said respective control units (3) on said module (C_i).

6. System for fault actuation on a plurality of modules (C1, C2 ... C_i ... C_n) of electronic equipment, characterised in that it comprises:
   - a plurality of respective control units (3) associated to respective fault actuating means (1) to control the selective fault actuation by said actuating means (1) according to respective fault actuation control signals,
   - a bus structure (4) for mutually connecting said control units (3),
   - means (5, 6) for generating fault actuation control signals, which generating means are interfaced (51) with said bus structure (4) so as to send said fault actuation control signals towards said control unit (3) through said bus structure (4).

7. System as claimed in claim 6, characterised in that said bus structure (4) is a balanced serial structure.

8. System as claimed in claim 6 or in claim 7, characterised in that said control units (3) comprise at least one part (10) powered through said bus structure (4).

9. System as claimed in any of claims 6 through 8, characterised in that said control units (3) comprise:
   - a first part (7, 8) driving said fault actuating means (1) and powered by a power supply source (V_{cc}) provided on the respective module (C_i), and
   - a second part (10), acting as interface towards said bus structure (4) and powered through said bus structure (42).

10. System as claimed in claim 9, characterised in that said first (7, 8) and second (10) parts of the control units are mutually connected through an optical coupler (9).

11. System as claimed in any of claims 6 through 10, characterised in that said control units (3) comprise:
   - respective driving circuits (7) for selectively controlling said fault actuating means (1), and

- a processing unit (8) responsive to said fault actuating signals coming from said bus structure (4) and arranged to selectively actuate said driving circuits (7) depending on said fault actuation control signals.

12. System as claimed in claim 11, characterised in that said processing unit (8) is a microprocessor.

13. System as claimed in any of the previous claims 6 through 12, characterised in that said control units (3) are configured for being mounted on said modules (C_i).

FIG. 1

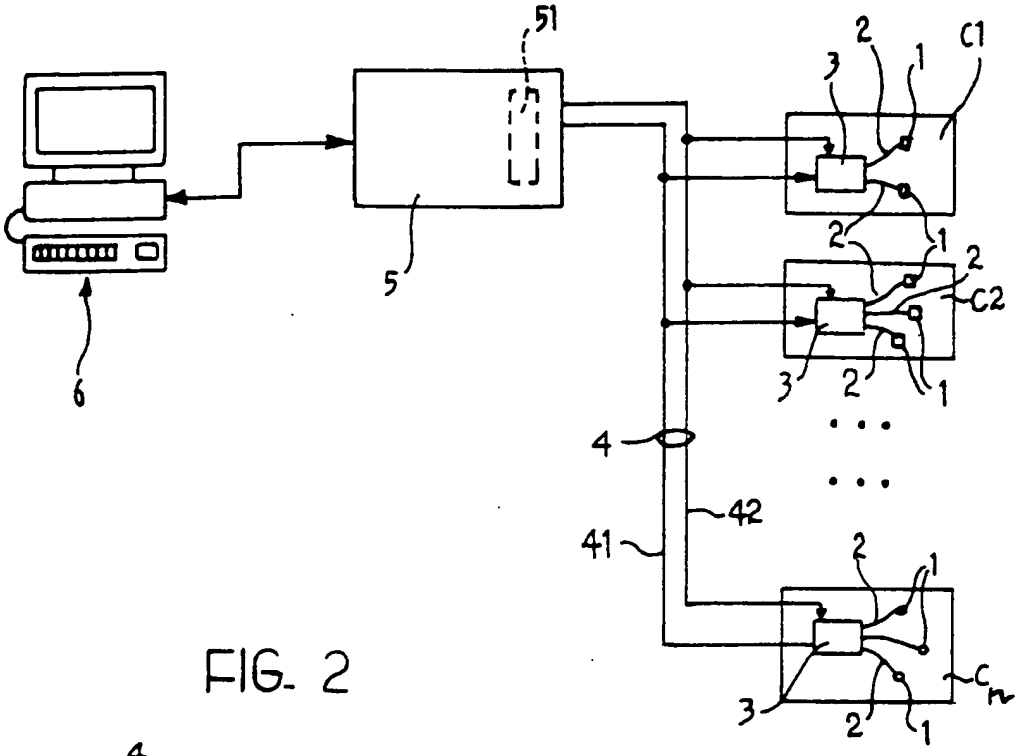
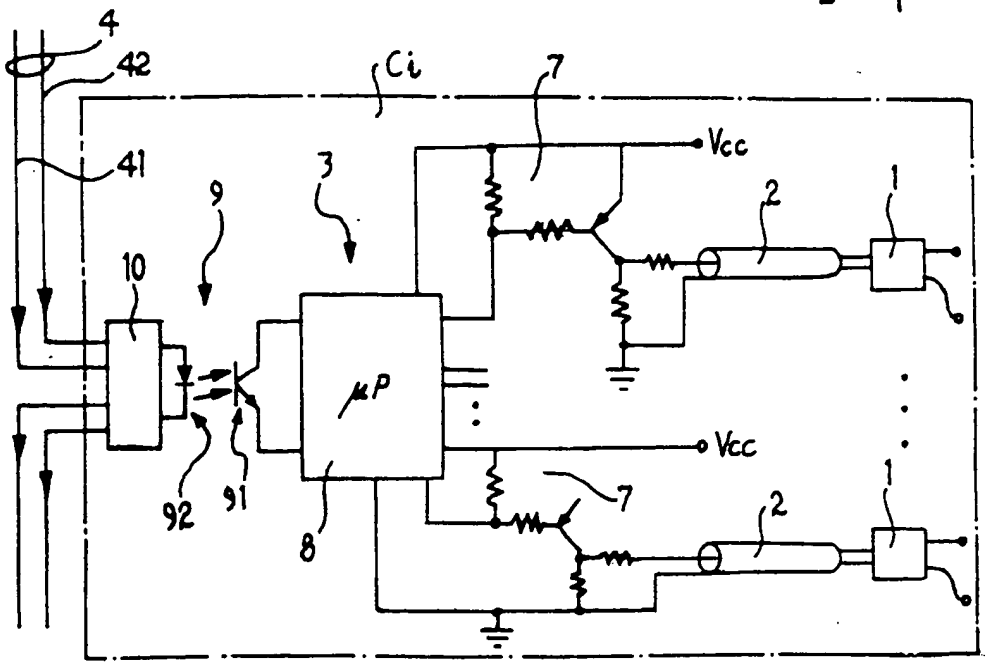


FIG. 2



INTERNATIONAL SEARCH REPORT

In Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04M3/10 H04M3/26 G01R31/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04M G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5 367 668 A (PANDOLFO MICHAEL A) 22 November 1994 (1994-11-22) abstract; figure 1 column 1, line 46 -column 5, line 63	1,6 3,8
X	DE 44 36 354 A (LINK HANNO) 25 April 1996 (1996-04-25) abstract; figure 1 column 1, line 2 -column 4, line 63	1,6
Y	US 4 467 220 A (PAGE RONALD) 21 August 1984 (1984-08-21) abstract; figure 1 column 4, line 48 -column 5, line 9	3,8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Information on patent family members

In Application No
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